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Extensible automated constraint modelling via refinement of abstract problem specifications

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Abstract
Constraint Programming (CP) is a powerful technique for solving large-scale combinatorial (optimisation) problems. Constraint solving a given problem proceeds in two phases: modelling and solving. Effective modelling has an huge impact on the performance of the solving process. This thesis presents a framework in which the users are not required to make modelling decisions, concrete CP models are automatically generated from a high level problem specification. In this framework, modelling decisions are encoded as generic rewrite rules applicable to many different problems.

First, modelling decisions are divided into two broad categories. This categorisation guides the automation of each kind of modelling decision and also leads us to the architecture of the automated modelling tool.

Second, a domain-specific declarative rewrite rule language is introduced. Thanks to the rule language, automated modelling transformations and the core system are decoupled. The rule language greatly increases the extensibility and maintainability of the rewrite rules database. The database of rules represents the modelling knowledge acquired after analysis of expert models. This database must be easily extensible to best benefit from the active research on constraint modelling.

Third, the automated modelling system Conjure is implemented as a realisation of these ideas; having an implementation enables empirical testing of the quality of generated models. The ease with which rewrite rules can be encoded to produce good models is shown.

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Furthermore, thanks to the generality of the system, one needs to add a very small number of rules to encode many transformations.

Finally, the work is evaluated by comparing the generated models to expert models found in the literature for a wide variety of benchmark problems. This evaluation confirms the hypothesis that expert models can be automatically generated starting from high level problem specifications. A method of automatically identifying good models is also presented.

In summary, this thesis presents a framework to enable the automatic generation of efficient constraint models from problem specifications. It provides a pleasant environment for both problem owners and modelling experts. Problem owners are presented with a fully automated constraint solution process, once they have a precise description of their problem. Modelling experts can now encode their precious modelling expertise as rewrite rules instead of merely modelling a single problem; resulting in reusable constraint modelling knowledge.

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